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A Preliminary Study on the Small Pelagic Fish Species Captured by Mid Water Trawls in the South-Eastern Black Sea Coasts of Turkey

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Abstract: Majority of Turkish fishery catch is obtained by the Black Sea and main fishing method used is the purse seining. Recent statistics indicates that the Black Sea is subject the excessive fishing power by purse seiners. This study aims to search the possibilities and benefits of introducing midwater trawl and outlines the optimum fishing parameters such as distance of fishing ground, towing speed, fishing time, fishing depth, sea surface temperature and fishing period for the Turkish Black Sea's small pelagic fishes namely anchovy *Engraulis encrasicolus*, sprat *Sprattus sprattus*, horse mackerel *Trachurus trachurus* and bluefish *Pomatomus saltatrix*. The study covers the fishing periods from 1998 to 2001 and was carried out in the area of southeastern Black Sea Coasts of Turkey. Four different types of trawl design were tested to collect data and the comparison of various fishing parameters between trawls and commercial purse seines was made by means of CPUE values. Catch efficiencies of single and pair vessel trawling were also investigated. The results show that midwater trawling can reasonable be the alternative method to harvest small pelagic species in the Black Sea. Midwater trawling therefore should be encouraged to reduce the detrimental effects of purse seiners (low selectivity and misusing) and to achieve sustainable fishing.

Key words: Black sea, purse seining, midwater trawling, pelagic species, fishing parameters, CPUE

INTRODUCTION

Turkey's fishery products are mainly based on small pelagic fishes namely, anchovy (*Engraulis encrasicolus*), sardine (*Sardina pichardus*) and horse mackerel (*Trachurus trachurus*). Nearly the most of the pelagic fishes are caught by purse seines. In the mid parts of the Black Sea coasts, some small amount of anchovy and sprat (*Sprattus sprattus*) catches are known to be provided by mid water trawls (Erden and Erokyuncu, 1997; Ayaz, 1998; Zengin, 2000). The Black Sea plays very special and significant role in Turkish fishery. Its contribution to total marine catches (505 000 t) is about 76.2% (TURKSTAT, 2003), except for the period of 1989 to 1991, which the Black Sea faced the most crucial crisis. Despite this crisis the Black Sea's share did not fall below 53% (TURKSTAT, 1990, 1991, 1992; Celikkale *et al*., 1999).

Beginning from the 1990's, fish stocks of the Eastern Black Sea has started to decline due to over fishing. Decrease in landed catch diminished the fisher's income. These greatly directed fishers to illegal fishing as well as increasing the fishing power imposed upon the stocks. It was also observed that bottom trawling started to take place even in the closed areas (Zengin *et al*., 1998; Zengin, 2000). On the other hand anchovy purse seines have been operated relatively shallow water columns. This resulted in severe damage on the benthic and pelagic fauna in the sub littoral zones (Zengin *et al*., 1998).

In Turkey, mid-water trawl was firstly used in 1978 by a private company. it was then adopted by regional fishers and started to be used in commercial fishing since 1982 with now around 40 vessels in the Central Black Sea, Samsun. Studies related to midwater trawling in Turkey are very limited and scarce of providing such detailed and satisfactory information as gear type, fishing criteria, bio-ecologic features of target species, distribution of non-target species and fishing efficiency (Ayaz *e t al*., 2000; Ozekinci and Hossucu, 2000; Kytagil and Bilecik, 1974). This study primarily aims to find an alternative way of decreasing excessive fishing power imposed on pelagic stocks of the Black Sea by purse seines. Therefore the possibilities of catching small pelagic fishes by mid water trawl rather than purse seines were investigated in the hope that this would more benefit fishers and fish stocks. It was also the purpose of this study to widen the implementation of mid water trawling and gain the access of catching non commercial species as sprat as well as try to put a new fishing model towards to conservation and sustainability of Turkish Black Sea fishery.

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Fig. 1: Map of the study area

MATERIALS AND METHODS

Study area: This study was conducted for the fishing seasons of 1998 to 2001, in the sub littoral region of the Black Sea, between Sinop and Hopa. Its location lies within the coordinates of 41°03′00″E, 41°01′12″N and 35°12′30″E, 42°01′09″N (Fig. 1). This area is the most productive region for the pelagic fisheries of Turkey and therefore majority of purse seine fleet are concentrated and developed in this region. The study was carried out in the fishing sessions of autumn, winter and spring targeting anchovy, sprat, horse mackerel and bluefish (*Pomatomus saltatrix*), maximum 5.5 nautical miles off the coast.

In this research, surveys were carried out by single and pair trawlers. The research vessel "R/V- Research-I" of Trabzon Central Fisheries Research Institute, 31.5 GRT, 24 m overall length and 350 HP main engine was used in single vessel trawling. Two commercial vessels of similar type were used in pair trawling operations; 92 and 75 GRT, 24.7 and 23 m overall length, respectively and having 515 HP engine in each.

Four types of trawl nets were used in the surveys. Trawl-I was the French type (FAO, 1978), Trawl-II was the Danish type, Trawl-III was the type used for herring (*clupea harengus*) fishing in Canada, Trawl-IV was the commercial mid water trawl used by local fishers. Codend mesh sizes for these trawls were 12, 16, 12 and 12 mm, respectively.

Suberkrub otterboards (Ferro, 1980; Ferro and Ritchie, 1984) each weighing 160 kg and 2.2 m^2 were used in the trawl nets. JMC 107 P GPS took coordinates of the survey stations. Vessel speed measurements were also taken by GPS. The sea surface temperatures were measured by means of echo sounder. Net sounders were replaced on various parts of the trawl gear (float line, tunnel, codend and doors) to control the position and spread of the gear. Optimum values of towing speed, fishing depth, distance from the shore; water surface temperature, fishing time and season were also determined.

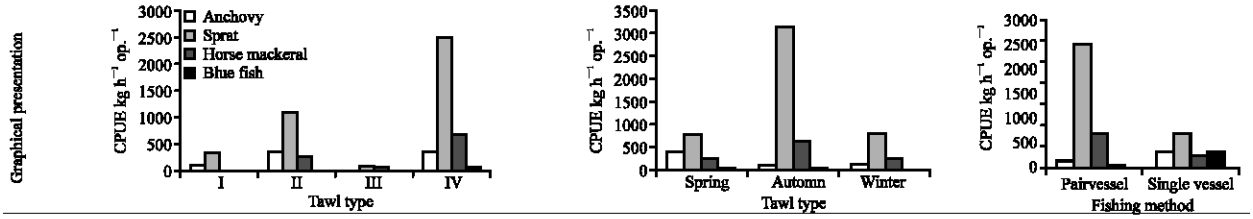
Type of gear and vessel, fishing date, location, distance from the shore, bottom depth, height of gear, towing speed, time and duration, sea surface temperature, fish species and weight were all recorded on data sheets. Catch samples were brought to laboratory for further measurements, length and weight frequency analyses. The Catch Per Unit Effort (CPUE) index has been used as an indication of fishing intensity (Cochran, 1977). Each CPUE value shows the variation of catch in relation to fishing effort (Phiri and Shirakihara, 1999).

RESULTS AND DISCUSSION

Catch per unit effort: CPUE values for anchovy, sprat, horse mackerel and bluefish according to trawl types were presented in Table 1. The maximum CPUE observed in Trawl-II for anchovy and in Trawl-IV for the others. Maximum average CPUE for these four species was found

Table 1: The CPUE values (kg.h^{-1}.op.$^{-1}$) for the target species by trawl types, seasons and trawling types.

	Trawl type				Seasons			Trawling type	
Species	I	II	III	IV	Spring	Autumn	Winter	Pair vessel*	Single vessel**
Anchovy	105.3 (45.0-225,0) n = 3	373.3 (37.0-1591.9) n = 6	-	121.3 (64.5-250.0) n = 4	415.1 (64.5-1591.9) n = 5	105.3 (45.0-225.0) n = 3	137.0 (37.0-270.0) n = 5	121.1 (65.5-250.0) n = 4	288.0 (37.0-1591.0) n = 9
Sprat	314.6 (54.0-685,7) n = 3	1101.3 (23.6-3363.0) n = 8	102.9 - n = 1	2483.9 (74.8-6000.0) n = 8	763.0 (74.8-1296.0) n = 7	3111.5 (54.0-6000.0) n = 6	816.8 (22.6-3363.0) n = 7	2483.9 (74.8-6000.0) n = 8	654.7 (22.6-3363.0) n = 12
Horse mackerel	-	267.2 (48.0-800,0) n = 7	27.4 - n = 1	668,8 (21.3-1760.0) n = 6	273.8 (21.3-526.3) n = 2	622.9 (48.0-1760.0) n = 6	271,0 (27.4-800.0) n = 6	668.8 (21.3-1760.0) n = 6	237.3 (27.4-800.0) n = 8
Bluefish	-	-	-	46.5 (1.1-245.5) n = 8	14.3 - n = 1	53.2 (1.1-245.5) n = 7	-	36.1 (12.5-245.5) n = 5	13.1 (1.1-25.6) n = 3
Average	210 (6)	615 (21)	65 (2)	952 (26)	532 (15)	1050 (22)	371 (18)	1116 (23)	304 (32)



*Surveys carried out by single vessel using Trawl-I, Trawl-II, Trawl-III, ** Surveys carried out by pair vessel using Trawl-IV

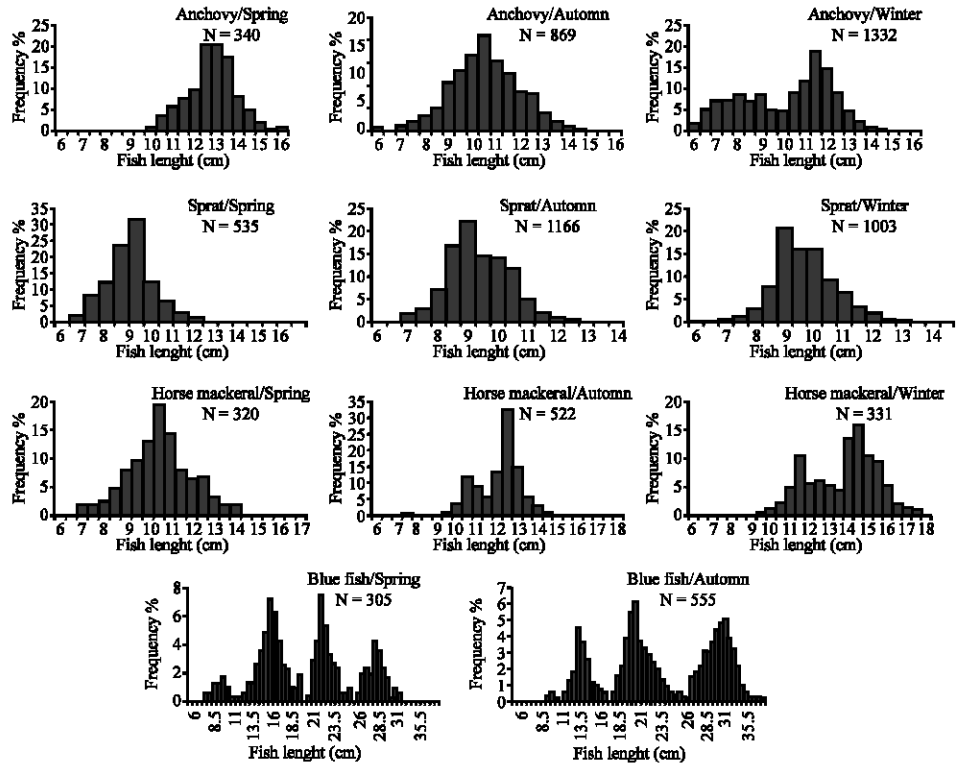


Fig. 2: Length-frequency distributions of target species by seasons

to be 952 kg h^{-1} op.$^{-1}$ in Trawl-IV. In case of seasons, CPUE is high in spring (March) for anchovy and in autumn for the others regardless with the trawl types. Maximum average CPUE for the target species was 1050 kg h^{-1} op^{-1} in autumn. Regarding with trawl types, it was found that the maximum values of CPUE were obtained in single vessel trawling for anchovy and horse mackerel, in pair vessel trawling for sprat and bluefish. Maximum average CPUE value for the target species of 1116 kg h^{-1} op^{-1} was computed in pair vessel trawling.

Table 2: Minimum-maximum and 50 % cumulative length* values (cm) of target species by seasons

	Spring		Autumn		Winter	
Species	$TL_{min-mak}$	$TL_{\%50}$	$TL_{min-mak}$	$TL_{\%50}$	$TL_{min-mak}$	$TL_{\%50}$
Anchovy	10.0-16.0	12.58	6.0-15.0	10.24	6.0-15.5	10.87
Sprat	6.0-11.0	8.07	6.0-13.5	8.99	6.0-14.0	9.32
Horse mackerel	7.0-14.0	10.27	7.5-16.0	13.00	9.5-18.5	13.78
Bluefish	8.0-31.0	20.19	10.0-35.5	22.00	-	-

*50 % cumulative lengths computed from median values by interpolation

Table 3: Some fishing parameters for the target species in midwater trawling (SE: standard error, n: number of survey)

	Parameter	Anchovy	Sprat	Horse mackerel	Bluefish
Towing	Mean±SE	2.6±0.16	2.6±0.11	2.9±0.11	3.1±0.15
speed	(Min-max)	(1.95-3.90)	(1.75-3.90)	(2.10-3.90)	(2.85-3.25)
(knot)	(n)	(21)	(30)	(19)	(8)
Fishing depth	Mean±SE	49.8±4.60	52.8±3.80	37.1±3.69	24.8±2.36
(m)	(Min-max)	(21.00-90.50)	(21.00-90.50)	(9.20-60.90)	(9.20-33.90)
	(n)	(23)	(30)	(18)	(8)
Distance of	Mean±SE	1.5±0.22	1.9±0.30	1.15±0.30	
fishing ground	(Min-max)	(0.45-4.88)	(0.45-4.60)	(0.40-4.80)	-
(mile)	(n)	(25)	(22)	(13)	
Sea surface	Mean±SE	12.6±0.59	13.2±0.51	14.7±1.10	20.7±0.66
temperature	(Min-max)	(8.10-17.10)	(8.10-17.10)	(8.10-17.10)	(17.10-21.50)
(^{0}C)	(n)	(21)	(30)	(18)	(8)

Length-frequency distribution: Distribution of length-frequency graphics of target species according to seasons was presented in Fig.2. Minimum and maximum cumulative length values corresponding to 50% of the population were shown in Table 2. It can be seen the cumulative 50% length values (and ranges) for spring season were found to be 12.6 cm (10-16) , 8.1 cm (6-11), 10.3 cm (7-14) and 20.2 cm (8-31) in spring, 10.2 cm (6-15), 9 cm (6-13.5), 13 cm (7.5-16) and 22 cm (10-35.5) in autumn, 10.9 cm (6-15.5), 9.3 cm (6-14) and 13.8 cm (9.5-18.5) in winter for anchovy, sprat, horse mackerel and bluefish, respectively. There is no data for the blue fish in winter.

Fishing parameters: Variation of CPUE in relation to towing speed, fishing depth, fishing distance, surface water temperature, fishing time and fishing season are presented in Table 3. The optimum towing speed for midwater trawls were found as 2.6 (1.95-3.9) knots for anchovy, 2.6 (1.75-3.9) knots for sprat, 2.9 (2.1-3.9) knots for horse mackerel and 3.1 (2.85-3.25) knots for bluefish. The fishing depth is closely related to seasonal and daily vertical and lateral migrations of the fish species. The optimum depths were 49.8 (21-90.5) m, 52.8 (21-90.5) m, 37.1 (9.2-60.9) m and 24.8 (9.2-33.9) m, for anchovy, sprat, horse mackerel and bluefish, respectively. The optimum fishing distances from the coast were found to be 1.5 (0.45-4.88) miles for anchovy, 1.9 (0.45-4.6) miles for sprat and 1.15 (0.4-4.8) miles for horse mackerel. There was no available data for the bluefish.

The water surface temperatures corresponding to optimum catches were 12.6 (8.1-17.1)°C, 13.2 (8.1-17.1)°C, 14.7 (8.1-17.1)°C and 20.7 (17.1-21.5)°C, for anchovy, sprat, horse mackerel and bluefish, respectively (Table 3).

Time periods within the day in which the most abundant catches were obtained for each species were 05.00-09:00 for anchovy, 05.00-10:00 and 13:00-17:00 for sprat, 05:00-08:00 and 15:00-21:00 for horse mackerel and 08:00-18:00 for bluefish (Table 3).

The most efficient fishing periods within the fishing season for each species were also determined as 15 November 15 December and 1 March 15 April for anchovy, 15 February 15 May and 1 October 15 November for sprat, 1 April 30 April and 1 October 30 November for bluefish, as two separate terms. However, for the bluefish the optimum term appeared relatively in a wider range of 1 October- 15 April (Table 3).

Anchovy fishing: Fishing trials have specified that more efficient fishing has taken place in about 50 m depth, 1.5 mile off the coast and the maximum catch has been obtained between 05:00 to 09:00 h. It was also possible to catch scattered and scarce anchovy shoals at later hours of the day by trawling. Anchovy fishing in the Turkish Black Sea coasts generally takes place between the Novembers to March. Average amount of catch in spring (4.6 t ves^{-1} day^{-1}) was higher than that of in autumn and winter.

Average catch rate of anchovy was found to be 17.5 t ves^{-1} day^{-1} in the peak season (December-January) with single vessel trawlers, whereas it was about 13.3 t ves^{-1} day^{-1} for purse seiners. Number of crew engaged in purse seiners (mother and carrier vessels) is about 25 (18-33), whereas it is maximum 6 for single trawler and for pair trawlers. Considering the vessel size, engine power and the cost of fishing gear, the midwater trawls appear to be more efficient than purse

seines. Engine powers used in seiners is about 2.5 times of trawler and cost of fishing gear is about 27 times of trawlers (Ivanov and Beverton, 1985).

In study of swept area by two types of gears per unit time, trawls were found be more advantageous. Although time spent at sea in a day is almost the same, the number of operations and time spent per operation is in favour of trawlers. Mean daily operation numbers for pair and single trawlers were 4 (2-5) and 7 (4-8), respectively, whereas it was 2 (1-5) for purse seiners. An average time spent per operation for seiners was maximum 4.5 h, whereas it was 3.2 h for pair and 1.7 h for single trawlers, i.e. one purse seine operation equals to 3 or 4 trawl operations. The 50% cumulative length values for all seasons were over 9 cm, which is the minimum legal size for anchovy. So the mesh sizes used at the codends for the trawls were reasonable from stock conservation viewpoint.

Sprat fishing: According to the result of this study the sprat gives maximum catch in two separate periods, autumn and spring. Out of these periods, it is commonly available in winter season together with anchovy as by-catch. It amounts 10% of the anchovy catch taken by purse seines in winter season. However, in December its contribution was about 60%. Two species may mix at some time of the day and separate later. Similar results were obtained by Samsun and Ozdamar, (1995). Avşar, (1993) reported that effect of purse seining in this period becomes more hazardous for sprat stocks.

Fishing time for sprat was estimated to be 11 h a day, corresponding to approximately 180 fishing days a year. This figure is similar to that of world trawling standards. For example fishing days at sea are 220 and daily operation hours are 10 to 12 in France (Pardanov, *et al*., 1997). There are about 40 fishing vessels capable for mid-water trawling in the study area and it is possible to catch 300-500 tonnes of sprat per day with these vessels. Scaling these figures up to the whole Turkish Black Sea coasts, it is possible to say sprat can be an alternative source of supply for the fishmeal plants and contributes to reduce existing excessive fishing power on anchovy stocks. Besides, sprat stocks are under exploited and have high recruitment rate and it is possible to utilize the sprat stocks with sustainable fishing (Bringel *et al*., 1995; Avsar and Bingel, 1994). Minimum allowable size for sprat is 9 cm, which reasonably coincides with 50% cumulative length determined in this study.

Horse mackerel and bluefish: Horse mackerel and bluefish stocks are also subject to over fishing, resulting decrease since the beginning of 1990's (Ozekinei *et al*., 2001). The ratios of under sized individuals for horse mackerel were 89% and 92%, for autumn and winter seasons, respectively. The corresponding ratios for the horse mackerel in the same seasons were 70 and 67%, respectively. Minimum allowable sizes for horse mackerel and bluefish are 13 cm and 20 cm, respectively. The 50% cumulative values obtained trawling trials are close to these figures (Table 2). But the ratios of undersized fish of horse mackerel (<13 cm) for the seasons of spring, autumn and winter were calculated as 93.7, 75.8 and 30.7%, respectively. For bluefish this ratios of fish (<20 cm) were 32.5 and 48.5% for spring and autumn, respectively.

CONCLUSION

It can be concluded that midwater trawl can be an alternative method to purse seine for fishing anchovy, sprat, horse mackerel and bluefish however, size selectivity should be increased using bigger codend mesh size (>16 mm) for horse mackerel and bluefish. Purse seines are almost non-selective, may catch undersized fish and by-catch rate is relatively high. Such undersized and untargeted fishes go directly to fishmeal and oil plants at a very low price. Since the fishmeal and oil plant is primarily dependent on anchovy caught by purse seiners, have encouraged over fishing. Therefore, it might be reasonable and useful to consider midwater trawling as an alternative method for anchovy due to the negative effects of purse seiners on the stocks. However, there are several points that makes difficult to implement this method at present. One is the lacking of legal measures to permit midwater trawls in the Black Sea and the other is unfamiliarity of the Turkish fishers to midwater trawling (Zengin *et al*., 2002). Therefore fishers should be encouraged and trained for the implementation of this method.

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